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ABSTRACT

Embedded Training (ET), means the use of sophisticated simulators for training that are embedded within operational equipment, is an emerging trend in military education for pilots, weapon systems personnel, etc. Training devices and ET are used to provide opportunities for both practicing job skills and original learning, and their effectiveness is measured by level of fidelity, cost, feedback, transfer of training to the operational equipment, and increase in skill level. ET has several advantages over traditional approaches in that it provides: (1) the opportunity for immediate hands-on experience with the operational system; (2) self-paced practice in critical hard-to-master skills; and (3) realistic, system-specific cues, responses, and information. It can also provide a mechanism for site-specific or operational-specific skill qualification testing. Based on computer technology, it is more appropriate to training tasks that require higher level cognitive skills, integrated performance of multiple skills, or team training. First used successfully in the 1950s in the U.S. Air Force, ET is now specified as the preferred training alternative for the design and development of training subsystems for Army materiel systems. Generally, ET progresses through three major analysis stages--concept formulation, training requirements analysis, and training system/component design. The use of the operational equipment to assist in the training of employees appears to be growing in both military and commercial applications. (A number of military projects utilizing ET are listed and five commercial applications are briefly described). (4 references) (BBM)

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# Title:

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# A Review of EMBEDDED TRAINING: "Status and Emerging Role in Training"

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Recent advances in computers have provided capabilities to develop sophisticated simulators for training and embedding the training within operational equipment. **Embedded training** is an emerging trend in military education. The use of simulators and embedded training (ET) has increased for training of pilots, weapon systems, etc. Some of the reasons for this are cost, safety, practice time, and the ability to train in adverse conditions at any time. The effectiveness of simulators and ET is measured by level of fidelity, cost, feedback, transfer of training to the operational equipment, and increase in skill level. This paper reports an investigation into the direction that embedded training is taking and examines lessons learned about the when and how to implement embedded training.

The purpose of training devices and embedded training is twofold: first, to provide opportunities for the student to practice his/her job performance, and; secondly, to provide original learning opportunities for the students. The term "Embedded Training" (ET) has been defined as training that is provided by capabilities designed to be built into or added onto operational systems to enhance and maintain the skill proficiency necessary to operate and maintain that equipment end item (1:4-8).

ET has several advantages over the traditional approaches of either supervised OJT (on-the-job training) or CBT (computer-based training) using stand-alone personal computers (PCs). First, embedded training allows immediate hands-on experience with the operational system. Second, ET provides self-paced practice in critical, hard-to-master skills without the man-intensiveness of over-the-shoulder tutoring. Finally, by stimulating actual workstation equipment, the

embedded training component can provide the learner with realistic, system-specific cues, responses, and information. Additionally, since it can use actual operational system data, it can provide a mechanism for skill qualification testing that is site-specific or operational-specific rather than generic.

Several types of tasks are better candidates for training via ET. These are summarized in Figure 1. Generally it is more appropriate to training tasks via ET which require higher level cognitive skills, the integrated performance of multipple skills, or team training. Tasks which are primarily rote actions or which require only lower levels of cognitive activity are poorer candidates for inclusion in ET.

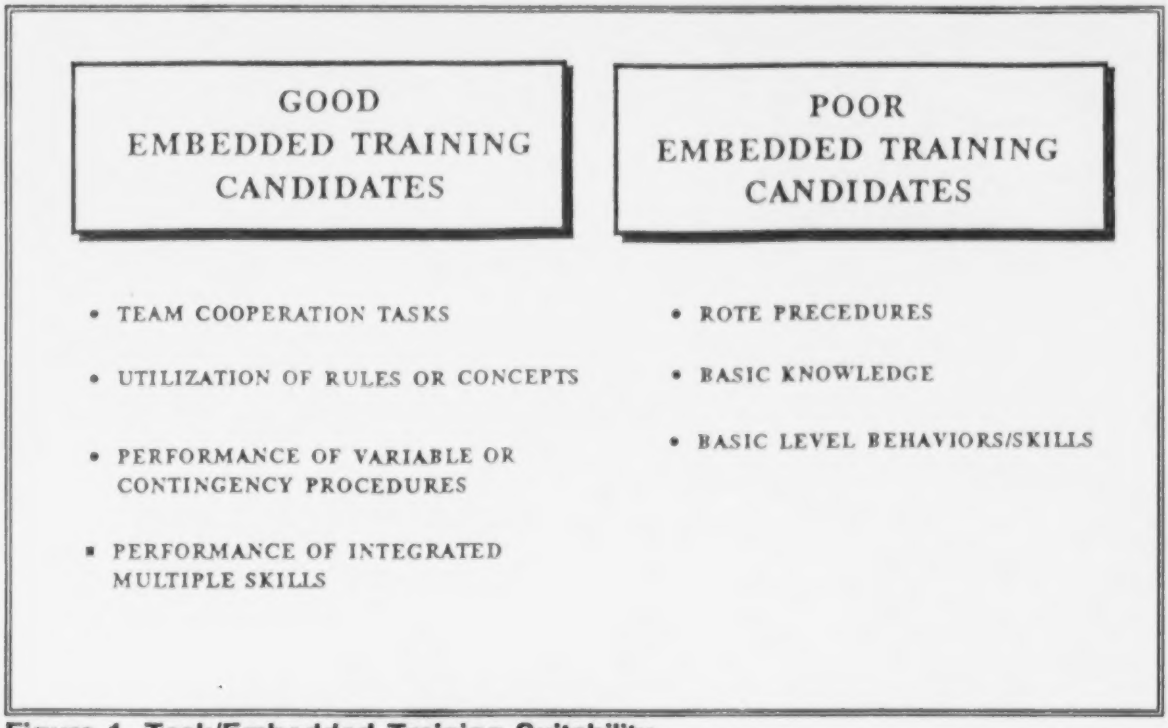
GOOD EMBEDDED TRAINING CANDIDATES
• TEAM COOPERATION TASKS
• UTILIZATION OF RULES OR CONCEPTS
• PERFORMANCE OF VARIABLE OR CONTINGENCY PROCEDURES
• PERFORMANCE OF INTEGRATED MULTIPLE SKILLS
POOR EMBEDDED TRAINING CANDIDATES
• ROTE PRECEDURES
• BASIC KNOWLEDGE
• BASIC LEVEL BEHAVIORS/SKILLS

**Figure 1. Task/Embedded Training Suitability**

The basic technology for ET is computer-based. Any control system which is digital in format and can provide sufficient memory, processing, and storage to handle the training database is a candidate for embedded training. ET concepts are still in an infancy stage when compared to advances in technology which might be utilized for ET. While ET has been utilized by the military on isolated projects for over 30 years, only recently has direction been given to thoroughly evaluate and consider ET as the preferred training alternative. ET is now specified as the preferred training alternative for the design & development of training subsystems in the development and follow-on Product Improvement Programs of all Army materiel systems by the Joint Chiefs of Staff (JCS).

systems, T1 Simulator for the Nike Hercules, the AN/TPQ-21 Basic Hawk Missile System, the Automated Programmed Instruction (API) and Astronaut training for NASA. During the 70s, ET was used for the upgrade of the Basic Hawk Missile System to the AN/TPQ-29 Improved Hawk Missile System. The Programming Language for Interactive Teaching (PLANIT) was also tested and validated in ET applications for teaching non-system-tied military skills during the MASSTER 122 test and for teaching tactical data system skills using the Tactical Fire Direction System (TACFIRE).

During the 80s, the application of ET has increased. Embedded Training was the training concept for the Fiber-Optic Guided Missile (FOG-M), the Army's Howitzer Improvement Program (HIP), and the SGT York. The Navy used ET on the Language Translator (L-TRAN) for the Naval Tactical Data System (NTDS), and AN/SPA-25G Radar Repeater, the On-Board Maintenance Trainer (OBMT) and the AEGIS Combat Training System (ACTS) to name a few. Also, the Air Force's On-Board Simulation (OBS) for the F-15, On-Board Electronic Warfare Simulator (OBEWS) and Pilot training uses ET.

Some of the ET programs currently under development for the Army are the following: Guard Unit Armory Device (GUARD) Full-Crew Interactive Simulator Trainer (FIST) - Armor (GUARDFIST-I), Light Helicopter (LHX) Family, Advanced Antitank Weapon System - Medium (AAWS-M), Multiple Integrated Laser Engagement System (MILES) - Air to Air Stinger (ATAS)(MILES-ATAS), the Armored Family of Vehicle (AFV) Program, and the Forward Area Air Defense System (FAADS). The Air Force is developing the use of ET for Aircraft cockpit training, High Speed Flyouts, and Reconnaissance Attack Fighter Training System (RAFTS) a T-38 replacement.

Army doctrine requires that identification of the training device needs to occur early-on during the formulation of the Required Operational Capability (ROC). During the development of the ROC, ET is considered and must be identified as a requirement, if applicable, in the operational characteristics and training assessment paragraphs. Identifying the requirement for ET as an essential characteristic of the system causes ET to be developed as part of the operational system. ET issues must be considered early enough to be incorporated into initial prototype designs. ET capabilities to train individual tasks through force-level collective tasks has been described in AR 350-38. Embedded training is described as encompassing four training categories:

(1) Category A - Individual/operator training objective: To attain and sustain individual, maintenance and system orientation skills.

(2) Category B - Crew training objective: To sustain combat ready crews/teams. This category builds upon skills acquired from

Several types of training objectives have been identified which more appropriately lend themselves to an Embedded Training approach. Generally tasks can be identified as appropriate for ET based on their criticality and perishability (2: 17ff). Criticality is a valuative judgement on the consequences on inadequate or slow task performance. Perishability is a rating indicating the skill decay rate of a component skill including decay of the ability to perform tasks or objectives which are dependent on that skill. Generally tasks which require the performance of integrated multiple-skills (high-workload, demanding components of performance), the utilization of rules or concepts (complex cognitive tasks), and the performance of variable or contingency procedures (requiring flexible, mediated responses) are more suitable for Embedded Training. Figure 2 summarizes primary ET task selection factors. Tasks which involve rote or invariate procedures, basic manipulative skills, factual knowledge, and basic level behaviors are usually less suitable for inclusion in embedded training. However, extenuating circumstances may justify their inclusion for ET. Embedded training is now recognized as a viable alternative for consideration when degradation in skill proficiency is likely due to infrequent application or where constant practice is needed to maintain performance proficiency.

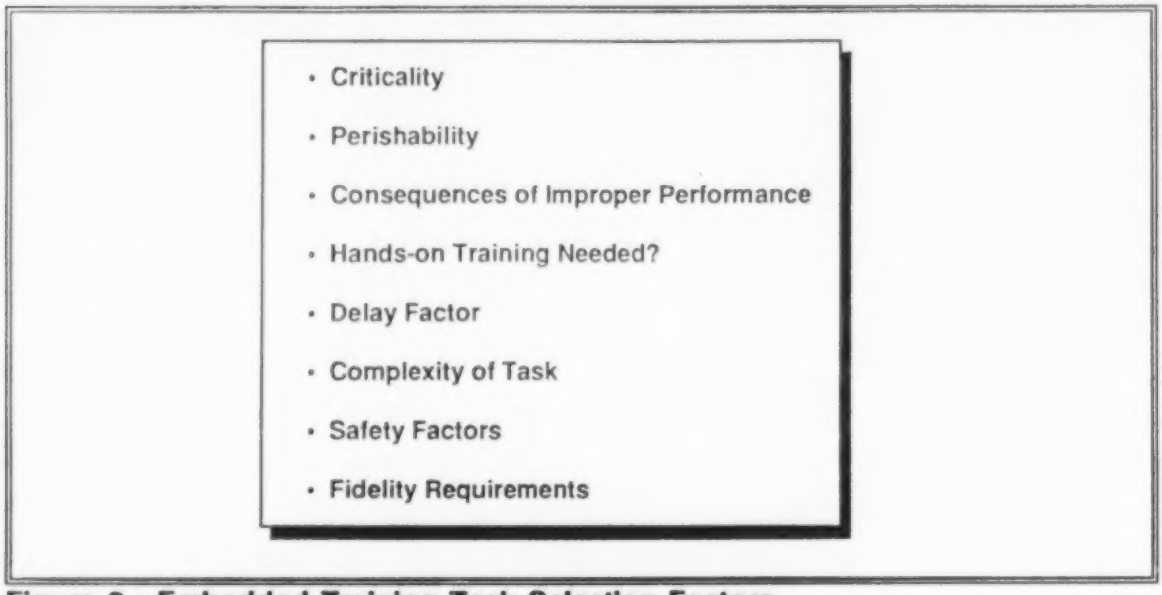


**Figure 2. Embedded Training Task Selection Factors**

ET was first successfully employed in the 50s with the development of the Semi Automatic Ground Environment (SAGE) System for the U.S. Air Force. While this embedded training application was successful, there was little movement to consider incorporation ET into other systems (3:515).

During the 60s, embedded training was used for the Pershing missile

Category A.

(3) Category C - Functional training objective: To train or sustain commanders, staffs, and crews/teams within each functional area to be utilized in their operational role.

(4) Category D - Force Level (Combined Arms Command and Battle Staff) training objective: To train or sustain combat ready commanders and battle staffs utilizing the operational system in its combat operational role.

The determination of appropriate category application for a given type of system/training strategy has not been established, nor have any heuristics for applying ET to meet the objectives of a given category been documented. Training developed follows AR 350-38, Training: Training Device Policies and Management, as a guide to define the term Embedded Training (ET). Through a thorough analysis using ARI 80-25 "How to Determine Training Device Requirements" and the new ARI ten volume Series: Implementing Embedded Training, the training developer determines the training need and requirements. In conjunction with this effort a methodology to determine the stimulus requirements and levels of fidelity needed for effective training is sometimes conducted based upon The Army Evaluation Group (TAEG) and contained in Reports No. 16 and No. 23, Focus on the Trained Man. These efforts are tailored to the process of specifying ET characteristics to achieve the most effective instructional delivery system.

Generally ET progresses through three major analysis stages. These stages are illustrated in Figure 3. During initial concept analysis an examination of the hardware and software constraints of the actual system must be conducted. Additionally tasks and human performance requirements for the system must be investigated. During the second phase, the information gathered during concept analysis is used to develop conditions and standards for task performance, task practice requirements, and to establish training priorities for ET. During the third phase of ET analysis the ET training component of the system is defined, and the detailed ET design is developed. This entire process is interative and must be adjusted to changes made in the developing system. Often the real system is limited in its capacity to handle the entire ET requirements. The ET component design must be maximized within the limits of the system.

Once the system design and the ET design are known and are relatively stable, development of the ET component must begin. This process is summarized in Figure 4. The elements illustrated this figure reflect the types of actions more typically associated with ISD. These actions can only occur when a detailed ET design exists defining the curriculum, the software and computer resources available, defining the interface with the operational system, and

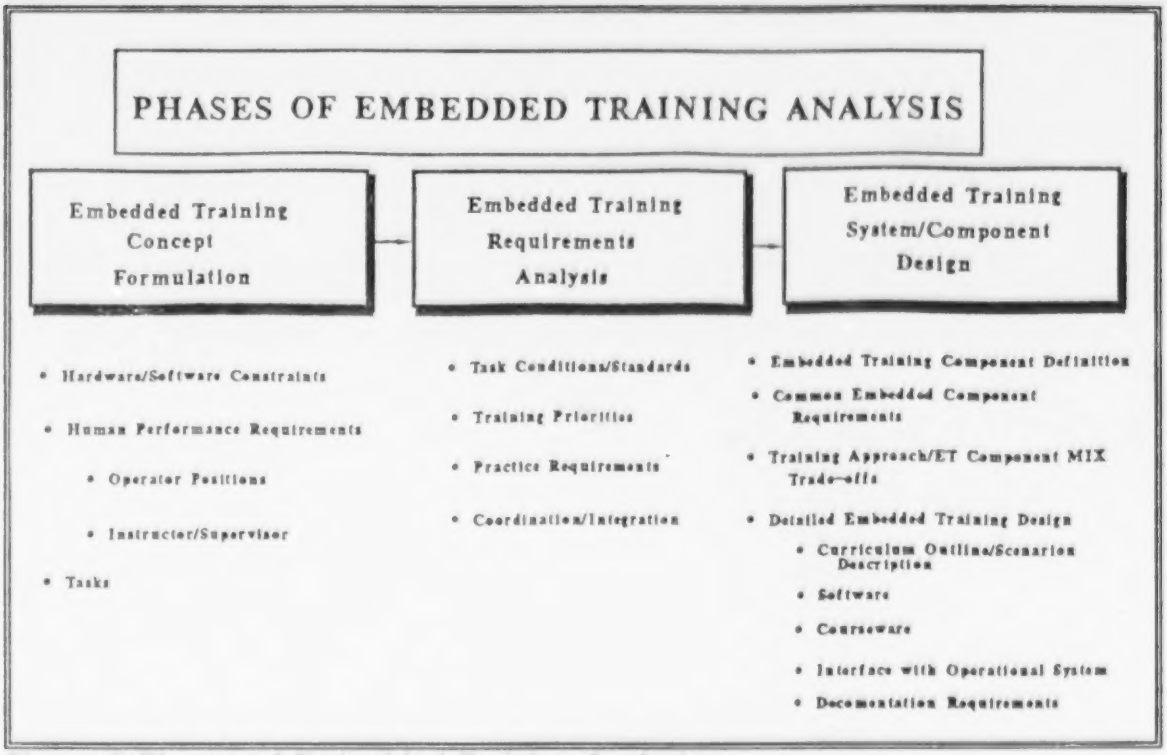


**Figure 3 Phases of Embedded Training Analysis**

defining the documentation requirements. A critical concern is the way the ET courseware will be activated and deactivated and the relationship between the ET and the system.

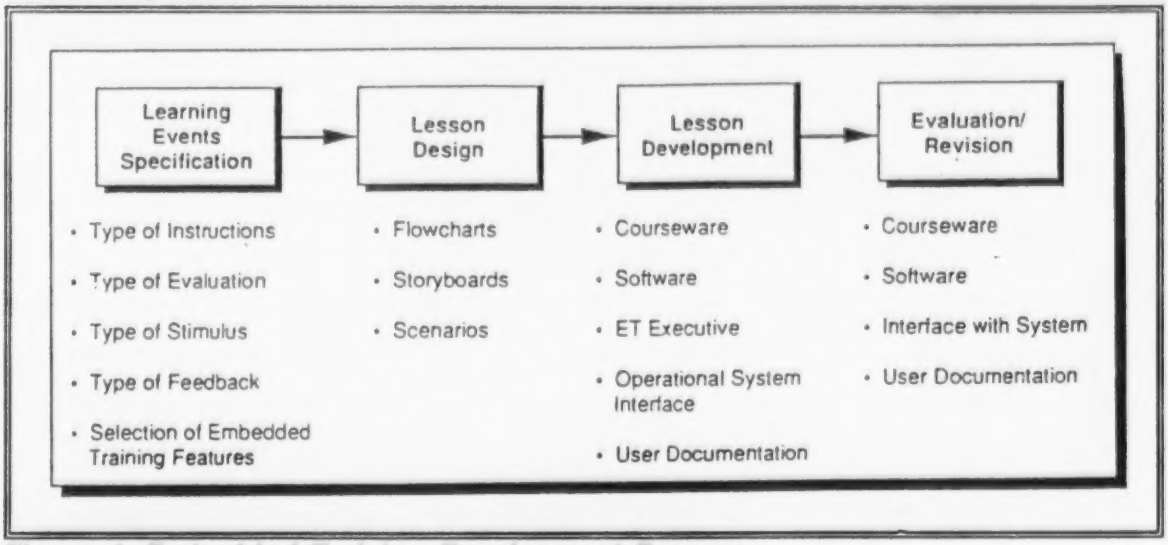


**Figure 4. Embedded Training Development Process**

for performance and work measurement. The facility is automated, paperless, integrated, interactive, and computerized. It has been nicknamed the "paperless factory". The system allows the operator to call up detailed sketches, photographs, even video, showing the work to be performed. The Manufacturing Integrated Production Planning System (MIPPS) can create text, tools, sketches, and anything else the planner requires. The system has a training data base that is used for this to ensure that the real-time control of the shop floor are the keys to the paperless factory of the future.

The use of the operational equipment to assist in the training of employees appears to be growing both in military and commercial applications. Embedded Training trains an individual on the operational equipment and is training effective. The problem of the transfer of training from the training system to the actual equipment is not an issue.

ET is not the end all to training problems. It is, however, another media method available to properly train individuals.
Based upon this, the use of embedded training in nonmilitary settings must be analyzed in the media selection process to ensure that the most appropriate method is utilized. Some future commercial applications of embedded training are the water works industry, assembly line companies, vocational education, shop training, user friendly computer training– word processing, spreadsheets, databases, etc., school systems, communication systems and airline cockpit training to name a few.

Non-military use of embedded training appears to be increasing. Five of the most noteworthy commercial applications are: the Rochester Gas and Electric Company, the New Hampshire Yankee, the Arizona Nuclear Power Project, the Ford Motor Company, and Martin Marietta Electronics Systems Company (ESC),

The Rochester Gas and Electric Company has established plant-specific training as a portion of the licensed operator training program for the Robert E. Ginna Nuclear Station. The simulator is functionally identical to the operational system but is maintained separately due to the unique safety concerns of the nuclear industry. The primary training subsystems involve stimulation of the Safety Assessment System (SAS) and the Plant Process Computer System (PPCS). The trainer simulates the SAS and the PPCS functions for all modes of operation including hot and cold startup, cold shutdown, prestart checks, preheating, power maneuvering, and normal, abnormal, and emergency operating conditions.

Both the New Hampshire Yankee which runs the Seabrook Station Nuclear Power Station in Seabrook, New Hampshire, and the Arizona Nuclear Power Project in Wintersberg, Arizona, have developed and adopted site-specific, computer-based simulation to train plant operators to handle every conceivable situation they might encounter in the real reactor. The simulator is used as one training device supporting a systematic program of training and licensing operators in the safe and efficient operation of a nuclear power station and provides periodic refresher training and recertification, as determined by the Nuclear Regulatory Commission (NRC) licensing requirements.

Ford Motor Company hired Applied Science Associates (ASA) to develop the Automated Assembly Line Trainer (AALT). The AALT is designed to provide diagnostics and instruction in using, maintaining, troubleshooting, and repairing the automated assembly line. The system uses Interactive Videodisc (IVD) technology to deliver training and job/decision-aid data. The AALT can stimulate any system component and can be readily tailored to any part on the assembly line.

Martin Marietta ESC has developed and implemented an Aerospace Planning, Execution, and Control System (APECS). APECS is a large-scale computer integrated manufacturing effort for a highly sophisticated electro-optical system. The system is manufacturing LANTIRN electro-optical night vision systems. APECS consists of four major subsystems: 1) a material resource planning and control system; 2) a manufacturing engineering system capable of generating and maintaining manufacturing bills of material, routing, standards, and process plans; 3) shop floor control of work priorities, shop operations control, and labor data collection, and; 4) a system that satisfies strict military standards

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5. Designing the ET Component
6. Integrating ET with the Prime System
7. ET Test and Evaluation
8. Incorporating ET into Unit Training
9. Logistics Implications
10. Integrating ET into Acquisition Documentation

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